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Thesium hispidifructum (Santalaceae), a New Hispidulous Species from Limpopo, South Africa and Notes on Enigmatic *T. celatum*

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Abstract: Two shrub-like *Thesium* species (subgenus *Psilothesium*) from the Limpopo and North West Provinces in South Africa are treated. Using morphological information from the literature, herbarium material (including types) and geographic information, specimens of the little-known *T. celatum* N.E.Br. and a new species, *T. hispidifructum* N.Lombard and M.M.leRoux sp. nov., are treated. A first comprehensive description of the Waterberg–Magaliesberg endemic, *T. celatum*, is provided along with diagnostic characters to distinguish it from its morphologically most similar-looking species, *T. burchellii* A.W.Hill. It has hitherto been classified as data deficient due to taxonomic reasons by the International Union for Nature Conservation (IUCN) but a status of Vulnerable is suggested. *Thesium hispidifructum* is recognised for the first time here and is endemic to Blouberg and Mount Letsjume. It is morphologically most similar to *T. disparile* N.E.Br. Its name was chosen with reference to its hispidulous to hispid indumentum covering the entire plant including the outside of the flowers and fruit. A threat status of vulnerable is proposed. Treatments of both species include detailed morphological descriptions, information on their distribution and habitat, comparisons and an identification key with morphologically similar species and photo plates.

Keywords: Blouberg; endemic; hemi-parasite; new species; *Psilothesium*; Thesiaceae; Waterberg

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1. Introduction

The large (±330 species) and globally distributed hemi-parasitic genus *Thesium* L. (Santalaceae [1]) has its centre of diversity in South Africa (±170 species). *Thesium* is monophyletic and sister to the monotypic genera *Lacomucinaea* Nickrent and M.A.García plus *Osyridicarpos* A.DC. [2,3]. There is substantial morphological variation in the genus [4,5] but it can usually be recognized by a combination of their (1) growth as hemi-parasitic herbs, subshrubs or shrubs, (2) linear or scale-like leaves that usually lack petioles, (3) dry, nut-like fruits that often form elaiosomes [2,4–6].

Many *Thesium* species are known for their problematic and often outdated taxonomy [7,8], which has resulted in *Thesium* being considered a high priority for taxonomic research in South Africa [9,10]. In addition, several South African *Thesium* species are known only from type collections—often of poor quality—and are not only enigmatic but also considered data deficient due to taxonomic reasons (DDT) by the International Union for the Conservation of Nature (IUCN).

As part of an ongoing effort to comprehensively revise the genus, taxonomic revisions of four African species groups have been published since 2018 [8,11–13], treating 24 species. To date, the taxonomy of 10 taxa previously listed as DDT on the Red List of South African plants [http://redlist.sanbi.org/, accessed on 15 October 2022] have been resolved. The renewed research interest in *Thesium*, as well as the continued contribution of citizen

scientists have led to the discovery and description of 11 southern African *Thesium* species new to science since 2018 [8,12–15]. This trend indicates that many *Thesium* species likely remain undiscovered.

The Waterberg region of the Limpopo Province, South Africa contains the Waterberg Biosphere Reserve which was designated a UNSECO site in 2001 (https://en.unesco.org/biosphere/africa/waterberg, accessed on 23 December 2022). A recent endeavour by several independent parties (e.g., [16]; Waterberg Biodiversity Project lead by Prof. Nigel Barker from the University of Pretoria) to record plants occurring in this area has revealed multiple populations of an unidentified *Thesium* species. The aim of this study is therefore to determine the identity of this *Thesium* species, whether it represents a new taxon or not.

2. Materials and Methods

The identity of the unknown *Thesium* species was determined through several lines of investigation. First, a thorough study of morphological characters was conducted on fresh specimens received from Manuel Popp and Linda Willemse. Measurements were taken either by hand using a ruler or those less than 3 mm using an Olympus DSX110 digital microscope with Olympus DSX software v. 3.1.9 (Olympus Corporation 2011–2019, Tokyo, Japan). All morphological characters known to be of diagnostic value (habit, growth form, plant indumentum, leaf morphology, inflorescence structure and flower morphology and indumentum), following previous studies (e.g., [6–8,12,13,17,18]) and expert knowledge, were studied and noted. Second, an attempt was made to key out the unknown species using two available identification keys and the measurements that were taken in step one [6,7]. Third, a list of *Thesium* species occurring in similar (bushveld) habitat within South Africa and neighbouring countries was compiled using distribution data from BODATSA (http://posa.sanbi.org/, accessed 2 September 2022), GBIF (https://www.gbif.org/, accessed on 2 September 2022) and iNaturalist (https://www.inaturalist.org/login, accessed on 2 September 2022). The list included species from South Africa, Namibia, Botswana, Zimbabwe, Zambia and Mozambique. Four, this list was narrowed down by excluding clearly morphologically distinct species that showed a markedly different morphology to the unknown species. Finally, morphological descriptions (from [6–8,17]), type specimens (from JSTOR Global Plants; https://plants.jstor.org/, accessed on 12 September 2022) and other herbarium specimens (from K and PRE) of the remaining morphologically similar species were compared to the unknown species. Collection information for specimens of morphologically similar species studied are provided in Supplementary Table S1.

All species circumscriptions presented here are based on a morphological species concept. Author citations follow the International Plant Names Index (https://www.ipni.org/, accessed on 12 September 2022) and herbarium abbreviations follow [19].

Information for the use in Red List status assessments are suggested based on the guidelines provided by the International Union for Conservation of Nature (IUCN Standards and Petitions Subcommittee 2017 [20]). The extent of occurrence and area of occupancy were calculated using GeoCAT software (http://geocat.kew.org/, accessed on 17 November 2022).

3. Results

A thorough study of all known diagnostically important morphological characters in *Thesium*, as defined and used in prior studies [3,6–8,11–15,17,18], revealed that six vegetative and 12 reproductive characters (Table 1) are useful when distinguishing among the unknown *Thesium* species and five morphologically similar species (*T. burchellii* A.W.Hill, *T. gracilarioides* A.W.Hill, *T. megalocarpum* A.W.Hill, *T. procerum* N.E.Br., and *T. whyteanum* Rendle). These characters are: (1) maximum plant height, (2) growth form, (3) habit, (4) branching pattern, (5) indumentum, (6) leaf length, (7) inflorescence type, (8) number of flowers per inflorescence, (9) bract length, (10) presence or absence of involucral bracts, (11) pedicel/peduncle length, (12) flower length, (13) hypanthium length, (14) flower lobe length, (15) style length, (16) stamen placement, (17) placental column shape, and (18) fruit

stipe length. Using a combination of these characters as well as geographical distribution information, the unknown *Thesium* species was determined to be the little-known South African species *T. celatum* N.E.Br. described in 1932 [17]. This study revealed a total of 13 gatherings (13 specimens) of *T. celatum* (see Additional specimens examined under *T. celatum*) that were included in this investigation.

Table 1. A comparison of the main diagnostic characters to distinguish among *Thesium celatum* and five morphologically similar species, *T. burchellii*, *T. gracilarioides*, *T. megalocarpum*, *T. procerum* and *T. whyteanum*. Missing data are indicated with "?" and uncertain data with "(?)".

	T. celatum	***T. burchellii***	***T. gracilarioides***	***T. megalocarpum***	***T. procerum***	***T. whyteanum***
Plant height	Up to 1.2 m tall	Up to 1 (?) m tall	Up 1 m tall	Up to 0.5 (?) m tall	Up to 1.5 m tall	Up to 0.6 (3?) m tall
Growth form	Shrub or subshrub	Shrub (?)	Shrub or subshrub	Subshrub	Shrub	Subshrub
Habit	Erect to spreading	Erect	Erect, spreading or decumbent	Erect	Erect	Erect
Branching pattern	Virgate	Erect	Intricate	Virgate	Intricate	Virgate
Indumentum	Glabrous to densely verruculose	Glabrous	Glabrous	Glabrous	Glabrous	Glabrous
Leaf length	2–22(–30) mm	±3–10 mm	3–14.5 mm	±4–30 mm	3–11 mm	±8–45 mm
Inflorescence type	Determinate spikate cymes (Solitary)	Flowers solitary/subsolitary	Determinate racemose cymes	Determinate racemose cymes	Determinate racemose cymes	Determinate racemose cymes (Solitary)
Number of flowers per inflorescence	(1)2–6	1(–2)	4–10	±3–8	4–16	(1)3–7(15)
Bract length	2–15 mm	±3.5–7 mm	2.3–7.0 mm	2–10 mm	2.5–5.5 mm	2–25 mm
Involucral bracts	(Absent) Present	(Absent) Present	Absent	Absent	Absent	Absent
Pedicel/peduncle length	N/A	0(–3) mm	0–1.5 mm	±1.3–25 mm	0–4.5(–6) mm	2–14 mm
Flower length	3.5–5.6 mm	2.6–3.6 mm	2.3–3.1 mm	2.5–3.6(–4.3) mm	2.5–4 mm	±2.6–3.6 mm
Hypanthium length	1.0–1.4 mm	?	1.3–2.3 mm	?	±1.2–3.1 mm	0.7–1 mm
Flower lobe length	1.2–2.5 mm	±1.0–1.5 mm	0.8–1.0 mm	±0.75–1.25 mm	0.9–1.3 mm	1.2–1.7(–2.4) mm
Style length	0.6–0.9 mm	±1 mm	0–0.4(–0.7) mm	±1.5 mm	0.6–0.8 mm	0.25–0.4(–1) mm
Stamen placement	In top half of hypanthium	?	At bottom of hypanthium	At hypanthium-lobe junction (?)	At hypanthium-lobe junction	At hypanthium-lobe junction
Placental column	±Undulate	?	Straight	?	Twisted	?
Fruit stipe	(0)0.6–2.2 mm	±0.5–1.3 mm	0 mm	±0.5–1.7 mm	±1.2–2.0 mm	±0.5 mm

Although *T. celatum* is morphologically similar to *T. gracilarioides*, *T. megalocarpum*, *T. procerum* and *T. whyteanum*, *T. celatum* is superficially most similar to *T. burchellii*. *Thesium celatum* and *T. burchellii* share tall robust stems (up to 1.2 m tall in *T. celatum* and up to 1 m tall in *T. burchellii*), leafy virgate branches, few-flowered inflorescences ((solitary) 2–6-flowered spike-like inflorescences in *T. celatum* and solitary or subsolitary flowers in *T. burchellii*) and flowers often subtended by involucral bracts. *Thesium celatum* generally has longer leaves (2–22(–30) mm long) and bracts (2–15 mm long), larger flowers (3.5–5.6 mm long) with stamens placed in the top half of the hypanthium and longer fruit stipes (up to 2.2 mm long), while *T. burchellii* has shorter leaves (±3–10 mm) and bracts (±5–7 mm), smaller flowers (2.6–3.6 mm) with stamens placed at the junction between the lobes and hypanthium and shorter fruit stipes (up to ±1 mm long). The placental column structure in *T. celatum* is undulate while it is unknown in *T. burchellii*. Based on the limited available information on their geographical distributions, these species are spatially separated. *Thesium celatum* is known from the Waterberg (Limpopo Province) and one population in the Magaliesberg (North West Province) and *T. burchellii* from the Northern Cape Province and Botswana. Morphological comparisons with other similar species (*T. gracilarioides*, *T. megalocarpum*, *T. procerum*, *T. whyteanum*) are provided in Figure 1 and Table 1.

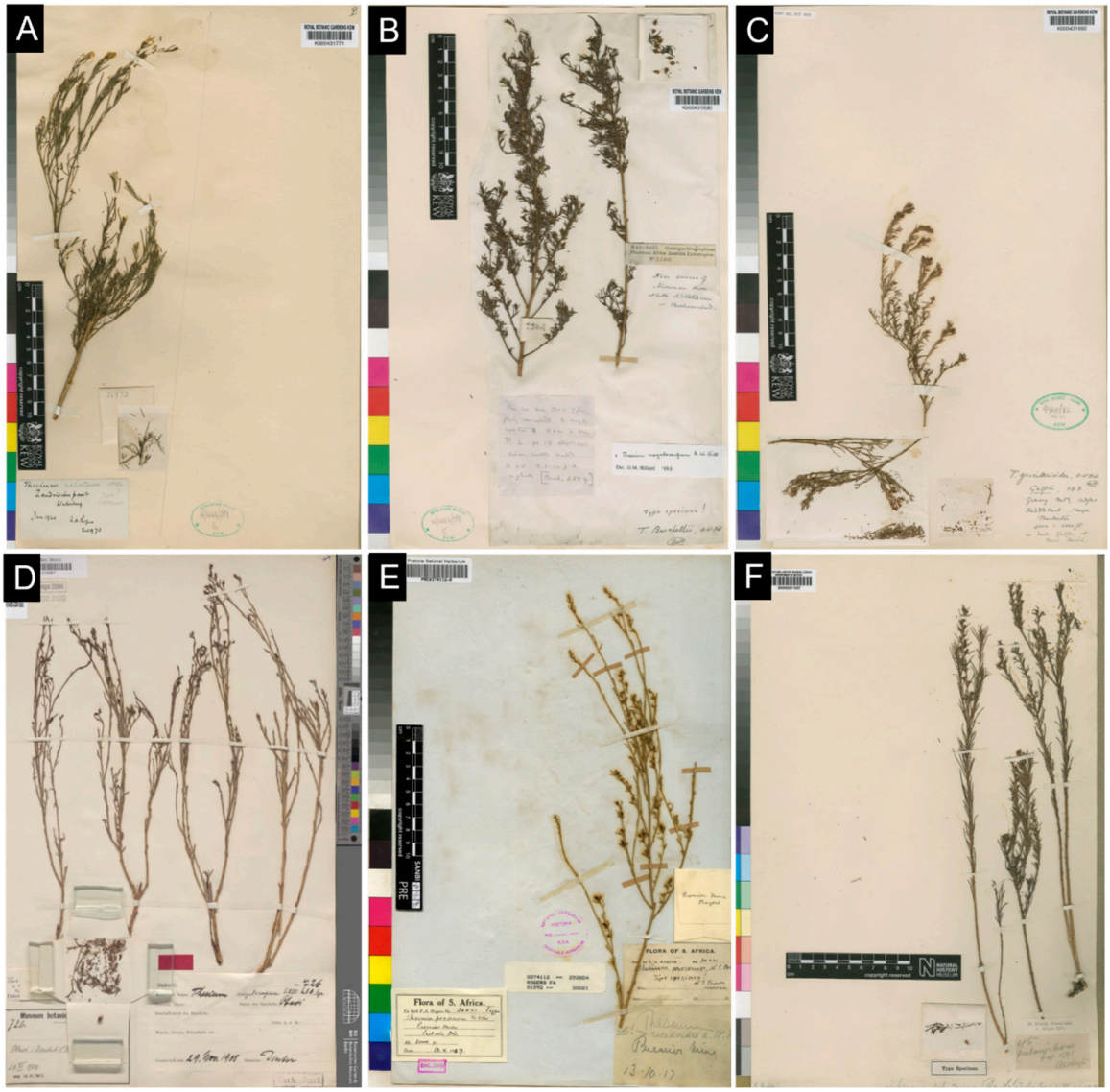

Figure 1. Scans of representative herbarium specimens of *Thesium celatum* (**A**) and five morphologically similar species *T. burchellii* (**B**), *T. gracilarioides* (**C**), *T. megalocarpum* (**D**), *T. procerum* (**E**), and *T. whyteanum* (**F**). Images reproduced with the consent of © The Board of Trustees of the Royal Botanic Gardens, Kew (**A**–**C**) (http://specimens.kew.org/herbarium/K000431771, http://specimens.kew.org/herbarium/K000431630, http://specimens.kew.org/herbarium/K000431692, accessed on 17 November 2022); ©Botanic Garden & Botanical Museum Berlin, Freie Universität Berlin, Germany (**D**); ©South African National Biodiversity Institute (**E**); and ©The Trustees of the Natural History Museum, London, England, reproduced under the terms of the Creative Commons Attribution License (CC BY 4.0) (**F**).

Surprisingly, the quest to identify *T. celatum* plants brought four additional PRE herbarium collections (see Additional specimens examined under *T. hispidifructum*) of another unknown *Thesium* species from Limpopo Province to the authors' attention. Specimens of the second species was mistakenly filed under *T. celatum*, perhaps due to their similar tall woody habits (a rare character state for the region as mentioned previously). The species in question is however immediately distinguishable from *T. celatum* and all other *Thesium* species in the northern provinces by its hispidulous to hispid indumentum which covers the entire plant including the outside of the flowers and the fruit. No species with this unique combination of characteristics is currently known in this region. Using the same methodology described for *T. celatum*, this second unknown species is believed to be new

to science. It is separated from three morphologically similar species (*T. disparile* N.E.Br., *T. rufescens* A.W.Hill, and *T. transvaalense* Schltr.) by a combination of seven vegetative and nine reproductive characters: (1) maximum plant height, (2) growth form, (3) habit, (4) branching pattern, (5) stem diameter, (6) leaf orientation, (7) leaf length, (8) inflorescence type, (9) number of flowers per inflorescence, (10) flower arrangement, (11) flower exterior indumentum, (12) flower length, (13) hypanthium length, (14) flower lobe length, (15) style length, and (16) fruit exterior indumentum (Table 2). It is seemingly endemic to Blouberg and Mount Letsjume in the Limpopo Province, which is adjacent to the Waterberg region where *T. celatum* occurs. The name *T. hispidifructum* N.Lombard and M.M.le Roux is suggested, after its hispid fruit.

Table 2. A comparison of the main diagnostic characters to distinguish among *Thesium hispidifructum* and three morphologically similar species, *T. disparile*, *T. rufescens*, and *T. transvaalense*. Missing data are indicated with "?" and uncertain data with "(?)".

	T. hispidifructum	***T. disparile***	***T. rufescens***	***T. transvaalense***
Maximum plant height	1 m	0.15(0.5?) m	?	0.3 m
Growth form	Shrub or subshrub	Herb	Subshrub	Herb
Habit	Erect(?)	Erect	Sprawling	Erect
Branching pattern	Intricate	Virgate	Divaricate	Virgate
Stem diameter	<4 mm	<1.5 mm	<1.5 mm	<1(4) mm
Leaf orientation	Ascending to spreading	Ascending to spreading	Spreading	Ascending to adpressed
Leaf length	4–15 mm	7–11 mm	±3.5–10 mm	3–5 mm
Inflorescence type	Determinate racemose cymes	Determinate racemose cymes	Determinate (?) spikate cymes	Determinate (?) spikate cymes
Number of flowers per inflorescence	5–10	±8–16	±10–20–many-flowered	±7–20–many-flowered
Flower arrangement	Compact	Lax	Compact	Lax to compact
Flower exterior	Hispidulous to hispid	Hispidulous (?)	Puberulent	Pubescent
Flower length	2.6–2.7 mm	±2.2–3.0 mm	±2.5 mm	±2 mm
Hypanthium length	0.3–0.6 mm	±0.5 mm	?	±0.5 mm
Flower lobe length	0.8–1.2 mm	±0.7–1.2 mm	±0.5–1.0 mm	±0.75 mm
Style length	0.2–0.4 mm	±0.5 mm	±0.75–1.0 mm	±0.5 (?) mm
Fruit exterior	Hispid	?	Glabrous (?)	Sparsely to densely pubescent

Thesium hispidifructum most closely resembles the Cape species *T. rufescens* in the hairy indumentum and small flowers (2.6–2.7 mm long in *T. hispidifructum* and ±2.5 mm long in *T. rufescens*) but differs in the robust (probably erect) stems, straight ascending leaves and raceme-like inflorescences (compared to slender (probably trailing) stems, spreading and recurved leaves and capitate spike-like inflorescences in *T. rufescens*). These two species are geographically disjunct. *Thesium hispidifructum* is restricted to the Limpopo Province while *T. rufescens* is known only from the Western Cape Province. Morphological comparisons between *T. hispidifructum* and other similar species (*T. disparile*, *T. transvaalense*) are provided in Figure 2 and Table 2.

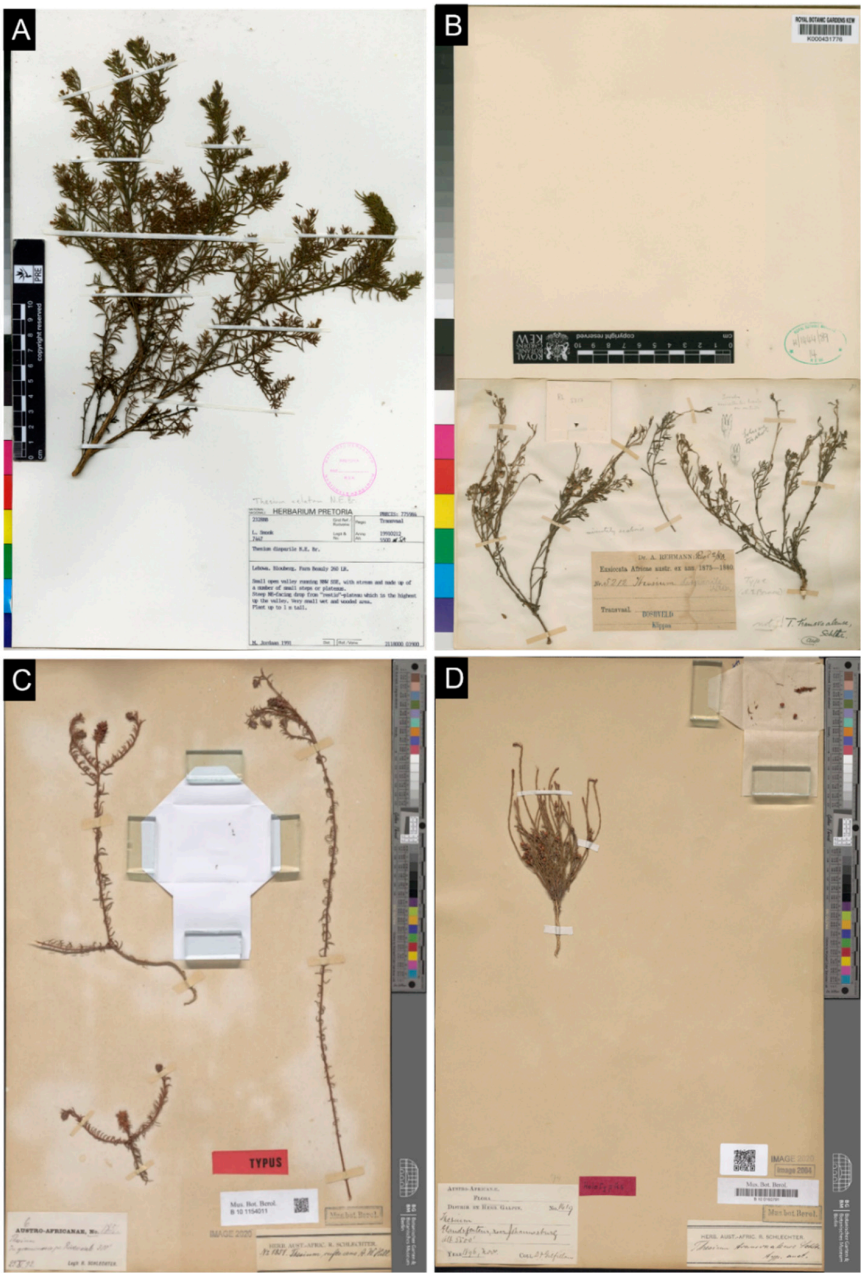

Figure 2. Scans of representative herbarium specimens of *Thesium hispidifructum* (**A**) and three morphologically similar species *T. disparile* (**B**), *T. rufescens* (**C**) and *T. transvaalense* (**D**). Images reproduced with the consent of the ©South African National Biodiversity Institute (**A**); ©The Board of Trustees of the Royal Botanic Gardens, Kew (**B**) (http://specimens.kew.org/herbarium/K000431776, accessed on 17 November 2022); and the Botanic Garden & Botanical Museum Berlin, Freie Universität Berlin, Germany (**C**,**D**).

3.1. Species Treatments

Thesium celatum N.E.Br. (Figure 3) in Man. Pl. Transvaal [Burtt Davy] 2: p. xxxii. 461 (1932).

Type: SOUTH AFRICA. Limpopo Province: Zandrivierspoort, Waterberg, January 1920, *F.A. Rogers 24973* (holotype K000431771!).

Descriptions: Shrub or subshrub, up to 1.2 m tall, rootstock a woody taproot; stems erect to spreading, up to 6 mm in diameter, virgate, glaucous, glabrous below and glabrous to densely verruculose above. Leaves mostly ascending, linear, 2–22(–30) × 0.1–0.75 mm, glabrous to densely verruculose on the margins and midrib or entire surface. Flowers sessile,

single in bract axils, occasionally solitary but mostly arranged in 2–6-flowered determinate spike-like inflorescences. Bracts and bracteoles 3–7, leaf-like but smaller, 2–15 mm long, forming an involucre. Perianth narrowly campanulate, 3.5–5.6 mm long, no "glands" observed on outside, externally glabrous; hypanthium 1.0–1.4 mm long; corolla lobes very narrowly triangular (almost linear), 1.2–2.5 mm long, apex slightly cucullate or sometimes somewhat pointed, with a dense apical beard and fringed margins. Stamens inserted in the top half of the hypanthium; anthers 0.4–0.8 mm long, included in- or rarely partially exerted from the hypanthium. Style 0.6–0.9 mm long, stigma often below anthers or sometimes reaching the lower half of the anthers. Placental column slightly to prominently undulate but not twisted; ovules (2)3(4). Fruit globose to elliptic, 6.5–8.4 × 2.4–3.2 mm including stipe and persistent perianth, stipe (0)0.6–2.2 mm long, persistent perianth 2.4–3.1 mm long, longitudinally and reticulately veined when dry, glabrous.

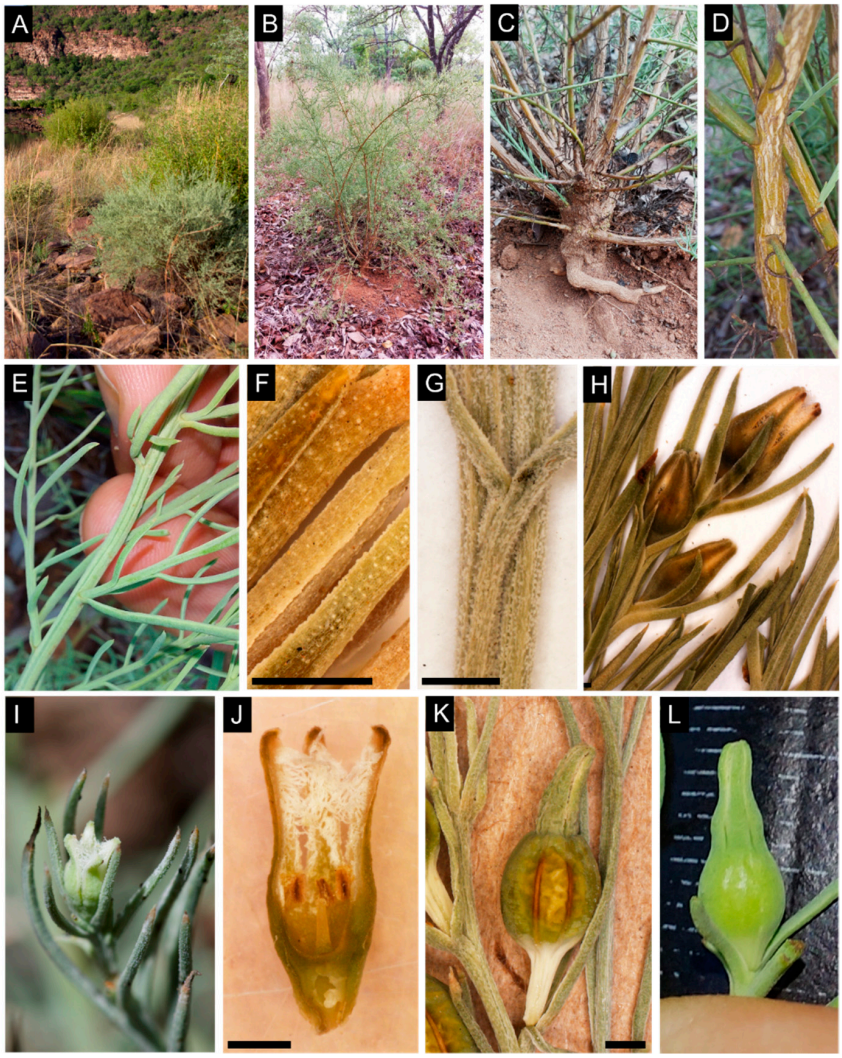

Figure 3. *Thesium celatum*. (**A**) Habitat. (**B**) Habit. (**C**) Woody rootstock. (**D**) Woody stem. (**E**) Sulcate herbaceous upper branches. (**F**,**G**) Variation in indumentum from nearly glabrous to densely verruculose. (**H**) Few-flowered spike-like inflorescence. (**I**) Solitary flower with involucral bracts. (**J**) Cross-section of a rehydrated flower showing the anthers inserted in the upper half of the hypanthium and the stigma reaching to the lower half of the anthers. (**K**) Dry fruit with longitudinal and reticulate veins, and a prominent stipe. (**L**) Fresh fruit without venation and lacking a stipe. The scale bars represent 1 mm. Photographs taken by L. Willemse (**A**,**I**), N. Lombard (**F**–**H**,**J**–**K**) and M.R. Popp ((**B**–**E**,**L**) via iNaturalist—https://www.inaturalist.org/observations/105570591, https://www.inaturalist.org/observations/103889320, accessed on 17 November 2022).

Diagnostic characters: This species is morphologically similar to *T. burchellii* sharing its tall (up to 1.2 m tall in *T. celatum*; up to 1(?) m tall in *T. burchellii*) woody and leafy habit, involucral bracts often present, flower lobes bearded at the inner apex and style length (0.6–0.9 mm long in *T. celatum*; ±1 mm long in *T. burchellii*). *Thesium celatum* differs from *T. burchellii* in the virgate branching pattern, long leaves (2–22(–30) mm long) and bracts (2–15 mm long), 2–6-flowered determinate spike-like inflorescences with occasional solitary flowers, large flowers (3.5–5.6 mm long) with long lobes (1.2–2.5 mm long) and large fruit (6.5–8.4 × 2.4–3.2 mm) (versus short leaves (±3–10 mm long) and bracts (±3.5–7.0 mm long), inflorescences with one or rarely two smaller flowers (2.6–3.6 mm long) with shorter lobes (±1.0–1.5 mm long) and smaller fruit (4.5–6.5 × 2.4–2.9 mm) in *T. burchellii*).

Note: Further useful morphological characters to consider for *T. celatum* include its stamens that are inserted in the top half of the hypanthium and the presence of undulate placental columns. These characters are unknown in *T. burchellii*.

Distribution and habitat: *Thesium celatum* is near endemic to the Limpopo Province in South Africa. It is known from 11 gatherings in the Waterberg area between Grootwater Nature Reserve, Naboomfontein, and Settlers Pride in Limpopo Province, and one isolated gathering in the vicinity of Brits (Nort West Province) (Figure 4). It grows solitary or in clumps in sandy soils between 1200 and 1590 m a.s.l. The habitat is predominantly open grassy savanna.

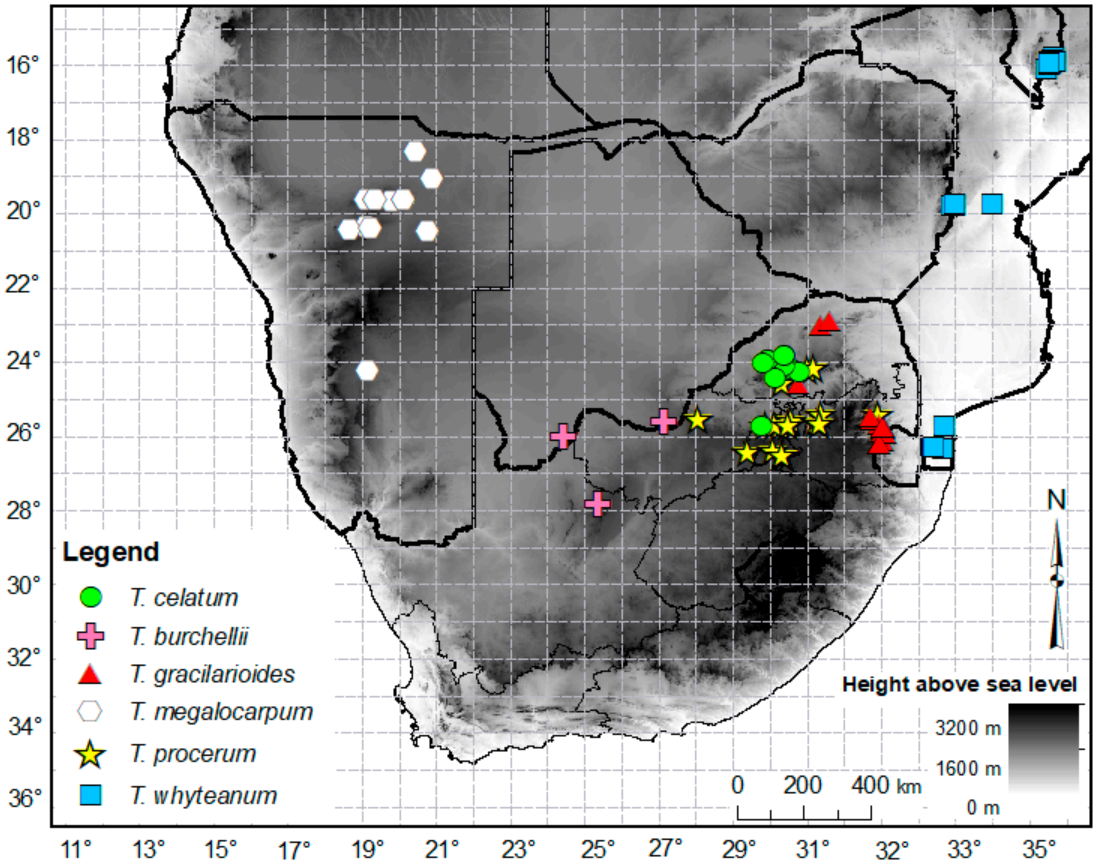

Figure 4. Geographical distributions of *Thesium celatum* (green circles) and five morphologically similar species, *T. burchellii* (pink crosses), *T. gracilarioides* (red triangles), *T. megalocarpum* (white pentagons), *T. procerum* (yellow stars), and *T. whyteanum* (blue squares).

Phenology and ecology: This species has been found in flower and fruit in January, June, August, September, and November. While *Thesium* species from this area normally flower between September and February, it is not uncommon for shrub-like species (e.g., *T. procerum*) to flower throughout the majority of the year ([8], personal observation).

Conservation status: *Thesium celatum* has an extent of occurrence (EOO) of 11 560 km^2 and an area of occurrence (AOO) of 36 km^2. It is known from 13 gatherings at seven to nine locations. Several subpopulations of this species have been observed for the first time in the past two years following field expeditions. It is therefore possible that more subpopulations remain undiscovered. Six of the known gatherings (*Jacobsen 2432*, *Popp s.n.*, *Popp s.n.*, *Popp s.n.*, *Van Vuuren 263* and *Willemse 10*) came from protected areas. The type gathering (*Rogers 24973*) came from a farm where most of the natural habitat has been transformed for agricultural purposes and it is very probable that this subpopulation has been lost or are at least severely impacted. Three of the known subpopulations (*Burgoyne 1746*, *Fourie 1512*, *Van Vuuren 263*) are potentially threatened by habitat loss and degradation due to urban and crop developments. The population is therefore believed to be declining. The remaining gatherings come from areas that appear not to be threatened. This species qualifies for a threat status of Vulnerable (VU) under Criterion B1ab(iii,iv,v) + 2ab(iii,iv,v) [20].

Additional specimens examined: SOUTH AFRICA. **Limpopo**: Ellisras District. Farm: Voorstandfontein 622 LQ. About 36 km SE of Ellisras and 43 km NNW of Vaalwater on R 33 between these towns, 25 September 2020, *S.P. Bester 15137* (PRE0876507), *15139* (PRE0876509). Farm Antjieshoop 266 KR, 2 km S from Jonkmansdrift shop, November 1980, *E. Fourie 1512* (PRE0617759); Pietersburg District, N of Naboomspruit, farm Kaalfontein, 25 June 1993, *P.M. Burgoyne 1746* (PRE0797871); Sterkrivierdam Nature Reserve, 9 January 1973, *N. Jacobsen 2432* (PRE0377518); Waterberg District, North of Naboomspruit, Farm Heinrichan Lephalala, central part of the farm on hills overlooking the Greater Lephalala river, 23 June 1993, *P.M. Burgoyne 1652* (PRE0801812); W of Moepel, 5 February 2022, *M. Popp s.n.* (PRE), *M. Popp s.n.* (PRE), *M. Popp s.n.* (PRE); Woodstock farm, next to the Mokolo river, 2 December 2020, *L. Willemse 10* (PRE). North West: *Jacksonstuin*, *noord liggende kloof Magaliesberg* (Jackson's Garden, N-lying gorge of the Magaliesberg), 1 August 1957, *D. van Vuuren 263* (K, PRE0379022).

Thesium hispidifructum N.Lombard & M.M.le Roux, sp. nov. (Figure 5)

Type: SOUTH AFRICA. Limpopo Province: Lebowa, Blouberg, Farm Beauly 260 LR, 12 February 1991, *L. Smook 7447* (holotype PRE0775984).

Diagnosis: *Thesium hispidifructum* is morphologically similar to *T. disparile* in its hairy indumentum, ascending to spreading leaves (4–15 mm long in *T. hispidifructum*; 7–11 mm long in *T. disparile*), flowers placed in determinate racemose cymes and flower lobes (0.8–1.2 mm long in *T. hispidifructum*; ±0.7–1.2 mm long in *T. disparile*) bearded at the inner apex. *Thesium hispidifructum* is easily distinguished from *T. disparile* by its tall robust stature (woody stems up to 1 m tall), intricate branching pattern and compact inflorescences with flowers solitary in the bract axils. Comparatively, *T. disparile* has a short slender stature (herbaceous stems up to 0.15(0.5?) m tall), virgate branching pattern and lax inflorescences with single flowers usually replaced by compound monochasial or dichasial cymes.

Description: Shrub or subshrub, up to 1 m tall, rootstock not known; stems erect, up to 4 mm in diameter, intricately branched above, hispidulous to hispid. Leaves spreading to ascending, sparse below and densely arranged above, often imbricate, linear, 4–15 × 0.3–1.0 mm, hispidulous to hispid. Flowers solitary in bract axils, arranged in 5–10-flowered determinate raceme-like inflorescences; pedicels 0–1.3 mm long. Bracts and bracteoles usually three, leaf-like but smaller, 2–7 mm long, not forming an involucre, bracts fused to at least half of pedicel. Perianth ±campanulate, 2.6–2.7 mm long, elongate receptacle often present, "glands" often visible on outside, exterior hispidulous to hispid; hypanthium 0.3–0.6 mm long; corolla lobes triangular, 0.8–1.2 mm long, apex very slightly cucullate, with dense apical beard of long hairs. Stamens inserted at base of corolla lobes; anthers ±0.3 mm long. Style 0.2–0.4 mm long, stigma below or reaching the bottom of anthers. Placental column straight; ovules 3. Fruit ± globose, 3.6–4.1 × 1.8–2.3 mm including stipe and persistent perianth, stipe ± 0.4 mm long, persistent perianth 0.9–1.3 mm long, longitudinally and reticulately veined when dry, hispid.

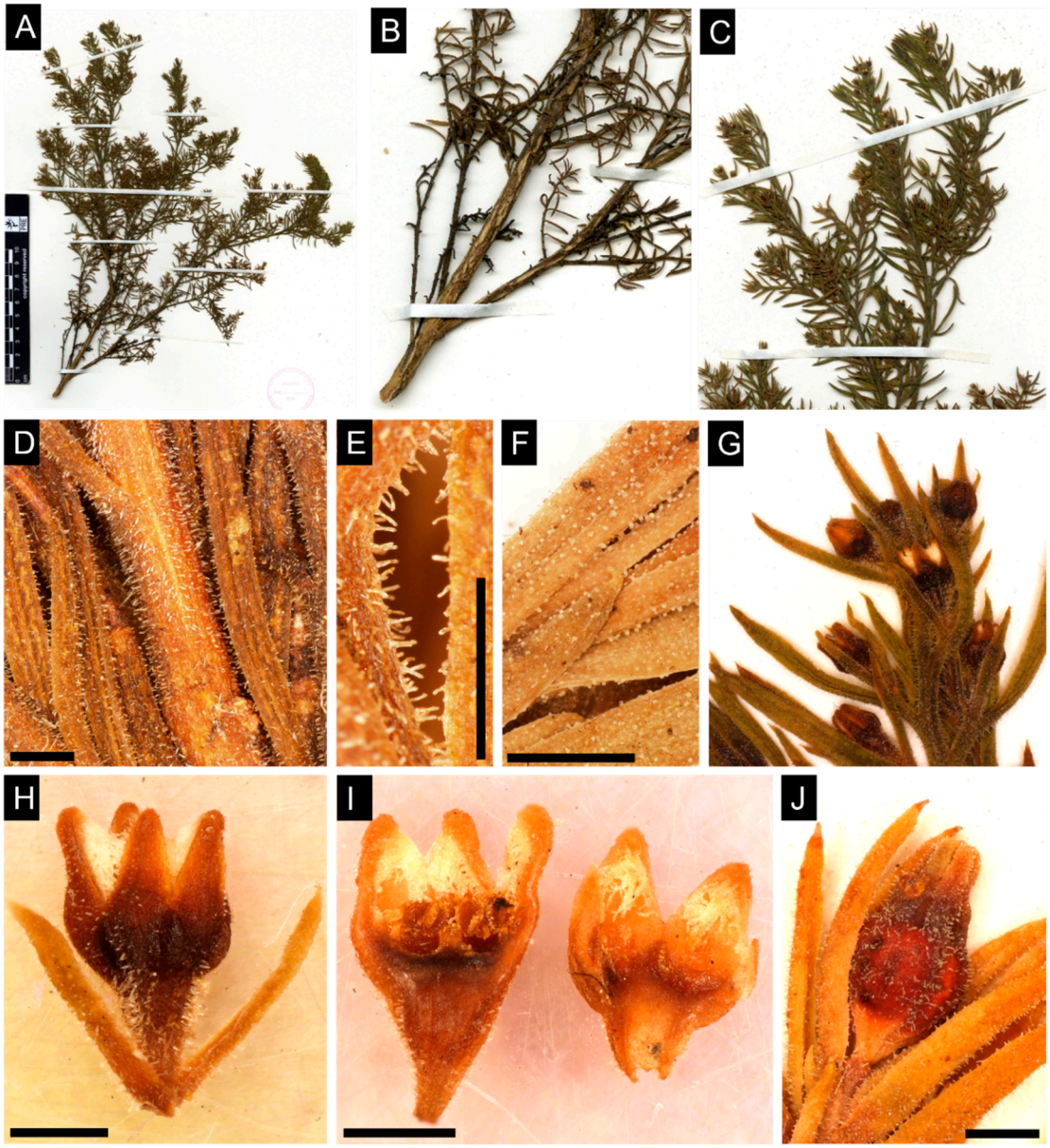

Figure 5. *Thesium hispidifructum*. (**A**) Habit. (**B**) Woody stem. (**C**) Branches. (**D**) Hispid branches and leaves. (**E**,**F**) Variation in the indumentum from hispidulous to hispid. (**G**) Compact spike-like inflorescence. (**H**) Exterior of a rehydrated flower with external "glands" and a hispidulous to hispid indumentum. (**I**) Cross-section of a rehydrated flower showing the anthers inserted at the base of the lobes and the stigma reaching to the bottom of the anthers. (**J**) Dry fruit with hispid indumentum. The scale bars represent 1 mm. Photographs taken by N. Lombard (**B**–**J**). Images © South African National Biodiversity Institute. Reproduced with the consent of the South African National Biodiversity Institute (**A**–**C**).

Distribution and habitat: *Thesium hispidifructum* is endemic to the Limpopo Province in South Africa, where it is known from only four gatherings between Blouberg and Mount Letsjume in the westernmost reaches of the Soutpansberg (Figure 6). Little is known about its habitat. It has been collected among grass in rocky areas as well as in wet wooded areas, on both south facing and northeast facing slopes at elevations between 1675 and 1980 m a.s.l. It is likely restricted to the Soutpansberg Mountain Bushveld [21] and Soutpansberg Summit Sourveld [21], but field studies are needed to confirm this.

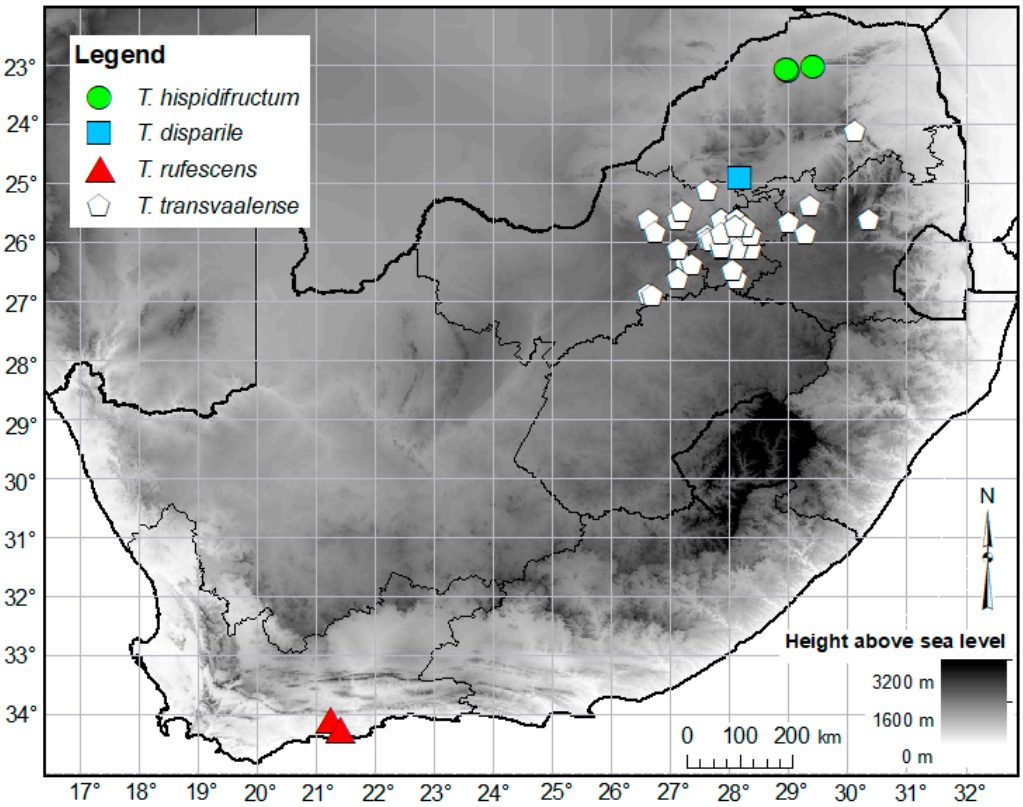

Figure 6. Geographical distributions of *Thesium hispidifructum* (green circles) and three morphologically similar species, *T. disparile* (blue square), *T. rufescens* (red triangles), and *T. transvaalense* (white pentagons).

Phenology: *Thesium hispidifructum* has been collected in flower and fruit in January, February, June, and July.

Etymology: The specific epithet *hispidifructum* refers to the hispidulous fruit of the species.

Conservation status: *Thesium hispidifructum* has an extent of occurrence (EOO) of 44 km^2 and an area of occurrence (AOO) of 12 km^2. It is known from only four gatherings at two to three locations in mountainous areas (Blouberg and Mount Letsjume), surrounded by much-transformed low-lying areas (Vivo and surrounds). As the most recent collection/observation of this species was in 1991, the state of these subpopulations is unknown, and needs to be verified during field studies. It is likely that the extensive human settlements and crop development in low-lying areas surroundings these mountains have already resulted in the loss of suitable habitat. Furthermore, expanding anthropogenic influences may easily push this very restricted species to extinction. It therefore qualifies for a threat status of Vulnerable (VU) under Criterion D2 [20].

Additional specimens examined: SOUTH AFRICA. **Limpopo**: Blauwberg, 10 May 1933, *A.C. Leeman 110* (PRE0374089); Blauwberg, near trig. beacon, 12 January 1955, *L.E. Codd and R.A. Dyer 9063* (PRE0374090); Zoutpansberg, Mt Letsjume, at foot, on S slope, 25 July 1981, *F. Venter* (PRE0620517).

3.2. Artificial Identification Key for T. celatum, T. hispidifructum and Eight Morphologically Similar Species

1a. Leaf exterior glabrous, or sparsely to densely verruculose; flower exterior glabrous (if verruculose then flower lobes ≥1.2 mm long)	
2a. Leaves up to 15 mm long; bracts up to 7 mm long	
3a. Inflorescences with solitary or subsolitary flowers; 1(–2) flowers per inflorescence	*T. burchellii*
3b. Inflorescences racemose cymes; 4–16 flowers per inflorescence	
4a. Placental column straight; fruit sessile, stipe absent	*T. gracilarioides*
4b. Placental column twisted; fruit stipitate, stipe ± 1.2–2.0 mm long	*T. procerum*
2b. Leaves up to 45 mm long; bracts up to 25 mm long	
5a. Inflorescences spikate cymes or flowers solitary, pedicels/peduncles absent; involucral bracts present or absent	*T. celatum*
5b. Inflorescences racemose cymes (flowers rarely solitary), pedicels/peduncles 1.3–25 mm long; involucral bracts absent	
6a. Bracts up to 25 mm long, reaching well beyond the top of the flowers; flower lobes 1.2–1.7(–2.4) mm long	
6b. Bracts up to 10 mm long, not reaching past the top of the flowers; flower lobes ± 0.75–1.25 mm long	
1b. Leaf exterior hispidulous, hispid, puberulent or pubescent; flower exterior hispidulous, hispid, puberulent or pubescent	
7a. Stems woody (up to 4 mm in diameter), up to 1 m tall	*T. hispidifructum*
7b. Stems herbaceous (if woody then sprawling and ≤1.5 mm in diameter), up to 0.3(0.5?) m tall	
8a. Inflorescences racemose cymes	*T. disparile*
8b. Inflorescences spikate cymes	
9a. Stems sprawling, divaricate; leaves spreading	*T. rufescens*
9b. Stems erect, virgate; leaves ascending to adpressed	*T. transvaalense*

4. Discussion

This study highlights the importance of fieldwork and the usefulness of information collected by both researchers and citizen scientists to aid taxonomy. Knowledge was generated through multiple collections made of a relatively poorly known *Thesium* species in the Waterberg. It was described by Brown in 1932 [18] using a cryptic diagnosis and was represented by limited material in herbaria. Through collections made over the past few months and photos taken of critical characters and uploaded onto iNaturalist, puzzle pieces were fit together to determine the identity of *T. celatum* and establish a better-informed, comprehensive morphological description. In addition, the collecting events stimulated further research and the recognition of a species new to science, *T. hispidifructum*, that would otherwise have gone unnoticed.

Although neither *T. celatum* nor *T. hispidifructum* have been included in molecular phylogenies of the genus (e.g., [4–21]), they both likely form part of subgenus *Psilothesium* (A.DC.) Zhigila, Verboom, and Muasya. Species of this subgenus (±100 species) occur throughout tropical and subtropical Africa, and South America and are characterized by amongst others their monoecious nature, subterete leaves or leaves with distinct adaxial and abaxial surfaces, and dry nut-like fruit [4], all characters congruent with those of *T. celatum* and *T. hispidifructum*.

Both *T. celatum* and *T. hispidifructum* are perhaps most notable in their woody habits that grow up to 1.2 m tall and 1 m tall, respectively. *Thesium* species from the northern provinces of South Africa (Gauteng, Limpopo, Mpumalanga and North West Provinces) are predominantly herbaceous with only a handful (e.g., *T. gracilarioides* A.W.Hill, *T. multiramulosum* Pilg., *T. procerum* N.E.Br.) having woody stems that regularly grow above 0.5 m tall. Other uncommon character states in *Thesium* species from this region include the sometimes scabrid indumentum of *T. celatum*, its long leaves (2–22(–30) mm long), bracts (2–15 mm long) and flower lobes (1.2–2.5 mm long), as well as the hispidulous indumentum (including the flower and fruit exteriors) of *T. hispidifructum*. The undulate placental column shape, found in *T. celatum*, is unique in the genus (straight or twisted in other species).

5. Conclusions

An unidentified *Thesium* species from the Limpopo and North West Provinces in South Africa has been identified as the little-known *T. celatum* following an in-depth study of morphology and geographical distribution. *Thesium celatum* is easily distinguished from similar *Thesium* species by amongst others its tall, robust habit (up to 1.2 m tall), glabrous to scabrous indumentum, long flower lobes (1.2–2.5 mm) and undulate placental columns. At the same time, a further unidentified *Thesium* specimens housed in PRE were determined to be new and endemic to the Limpopo Province, characterised by amongst others its tall robust habit (up to 1 m tall), densely papillose to hispid indumentum, short flower lobes (0.8–1.2 mm) and straight placental columns. It is named *T. hispidifructum* after its hispid fruit, a rather rare character state in *Thesium*. This study once more alludes to the plethora of remaining taxonomic work needed in *Thesium*, a genus that has not been revised in southern Africa for almost 100 years as well as the usefulness of collecting activities and the help citizen scientists provide.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/taxonomy3010009/s1, Table S1: Specimen information of eight *Thesium* species morphologically similar to *T. celatum* and *T. hispidifructum*, examined during this study.

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Conflicts of Interest: The authors declare no conflict of interest.

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